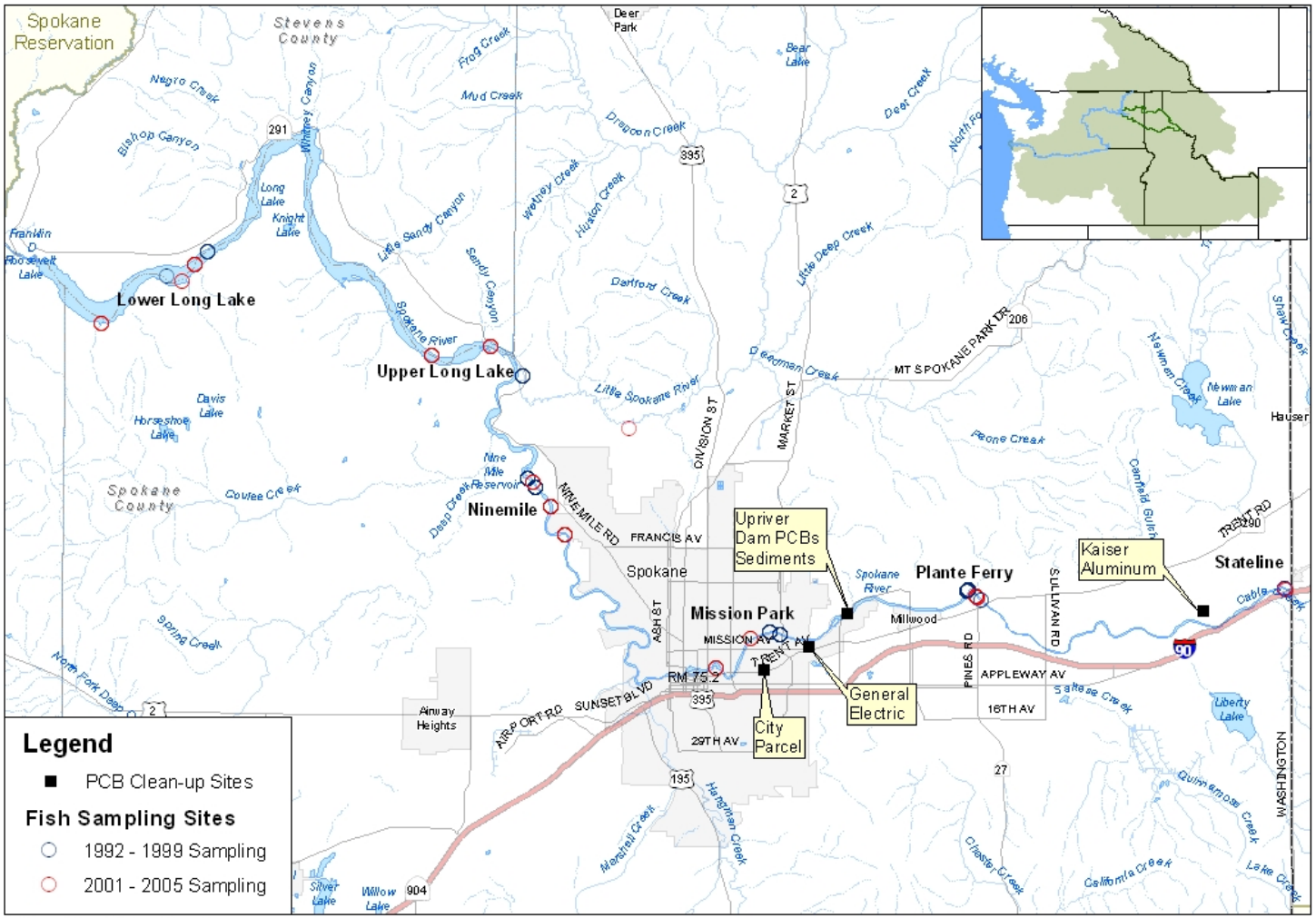
Columbia River State of the River Report
Indicator Section Matrix
Mountain Whitefish, Rainbow Trout and Sucker in the Spokane River – PCBs & PBDEs

Rainbow Trout, Mountain Whitefish and Sucker in the Spokane River have experienced significant decreases of PCB body burdens in the time between 1992 and 2005 in almost every reach of the river. These decreases are attributed to cleanup of hazardous waste sites and NPDES dischargers reducing their inputs. At the same time significant increases of PBDEs have been observed in Mountain Whitefish and Rainbow Trout in the river. In one section of the river, just below the Spokane metro area, large increases of PBDE body burdens have occurred in six years and levels recorded in mountain whitefish are significantly higher than for any other fish samples recorded in the Pacific Northwest.

The Spokane River originates at the outlet of Lake Coeur D'Alene in northern Idaho, flows west into Washington and through the Spokane metropolitan area. Downstream of Spokane, it forms the southern border of the Spokane Indian Reservation and flows into Lake Roosevelt, the Columbia River's 150 mile impoundment upstream of Grand Coulee Dam.



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Spokane River PCBs and PBDEs in Fish

Washington Department of Ecology has sampled fish in the Spokane River for PCBs since the 1990s and found high levels, particularly near the city of Spokane's industrial areas. The Washington Department of Health issued consumption advisories for PCBs in Spokane River Fish in 1996 and there are still advisories in place despite a decline in PCB levels. PBDEs were sampled for in the 1999 and 2005 Ecology studies. The effects of PBDEs are still being evaluated and there are not yet effects endpoints for these pollutants. There is no effects data specific to sucker, rainbow trout or whitefish in the Spokane River area. Some laboratory studies of effects of PCBs and PBDEs have been conducted on rainbow and other trout.

Mountain whitefish, rainbow trout and bridgelip and largescale sucker are species native to the Columbia Basin. They are widely distributed in the basin. Population trends and status of these species have not been studied.

PBDEs

Total PBDEs in Spokane River Fish (ug/kg wet wt.)

Reach	River Miles	Species	1999 Samples			2005 Samples		
			N	mean	Range	N	Mean	Range
Fillet Samples								
Stateline	95.5 - 96.1	Largescale Sucker	5 discrete	52	17 - 81			
		Rainbow Trout	6 discrete	161	66 - 230			
Plante Ferry	84 - 86	Largescale Sucker	5 discrete	23	7.8 - 53			
		Rainbow Trout	6 discrete	132	37 - 370	3 composite	73	54 - 87.6
Mission Park	74.5 - 78	Largescale Sucker	5 discrete	40	23 - 110			
		Mountain Whitefish	5 discrete	202	53 - 360	3 composite	316	299 - 336
		Rainbow Trout	5 discrete	99	64 - 196	3 composite	23	21.5 - 24.2
Ninemile	62 - 65	Largescale Sucker	6 discrete	127	89 - 240			
		Mountain Whitefish	5 discrete	532	164 - 940	3 composite	886	776 - 1019
		Rainbow Trout	8 discrete	184	122 - 330	3 composite	340	245 - 487
Upper Long Lake	50 - 57	Mountain Whitefish				3 composite	145	133.3 - 162.8
Lower Long Lake	39 - 41	Mountain Whitefish				6 discrete	91	44.5 - 179.9
Wholebody Samples								

Stateline	95.5 - 96.1	Largescale Sucker	1 composite	128		3 composite	156	136.5 - 167.8
Plante Ferry	84 - 86	Largescale Sucker	1 composite	43		3 composite	113	67.2 - 202.5
Mission Park	74.5 - 78	Largescale Sucker	1 composite	130		3 composite	74	70 - 77
Ninemile	62 - 65	Largescale Sucker	1 composite	404				
		Bridgelip Sucker				4 composites	414	299.7 - 582
		Mountain Whitefish	1 composite	1,040		2 composite	4,040	3,426 - 4,765
		Rainbow Trout	1 composite	480		2 composite	1,794	1,532 - 2,100
Upper Long Lake	50 - 57	Largescale Sucker				3 composite	463	378.5 - 595.4
Lower Long Lake	39 - 41	Largescale Sucker				3 composite	138	74 - 293

*Total PBDEs in this document refers to the sum of bde 47 and bde 99. These are the two congeners that were delineated in both the 1999 and 2005 studies and the sum of them is used for a more accurate comparison. Because the 2005 study includes data on 12 congeners the values in this document understate the levels of total PBDEs documented by that study by an average of 18% and a range of 25% to 12%.

At this time no toxicity thresholds or benchmarks have been established for PBDEs. The limited effects data available for PBDEs is inconclusive as to whether PBDEs may be affecting fish in the Spokane River.

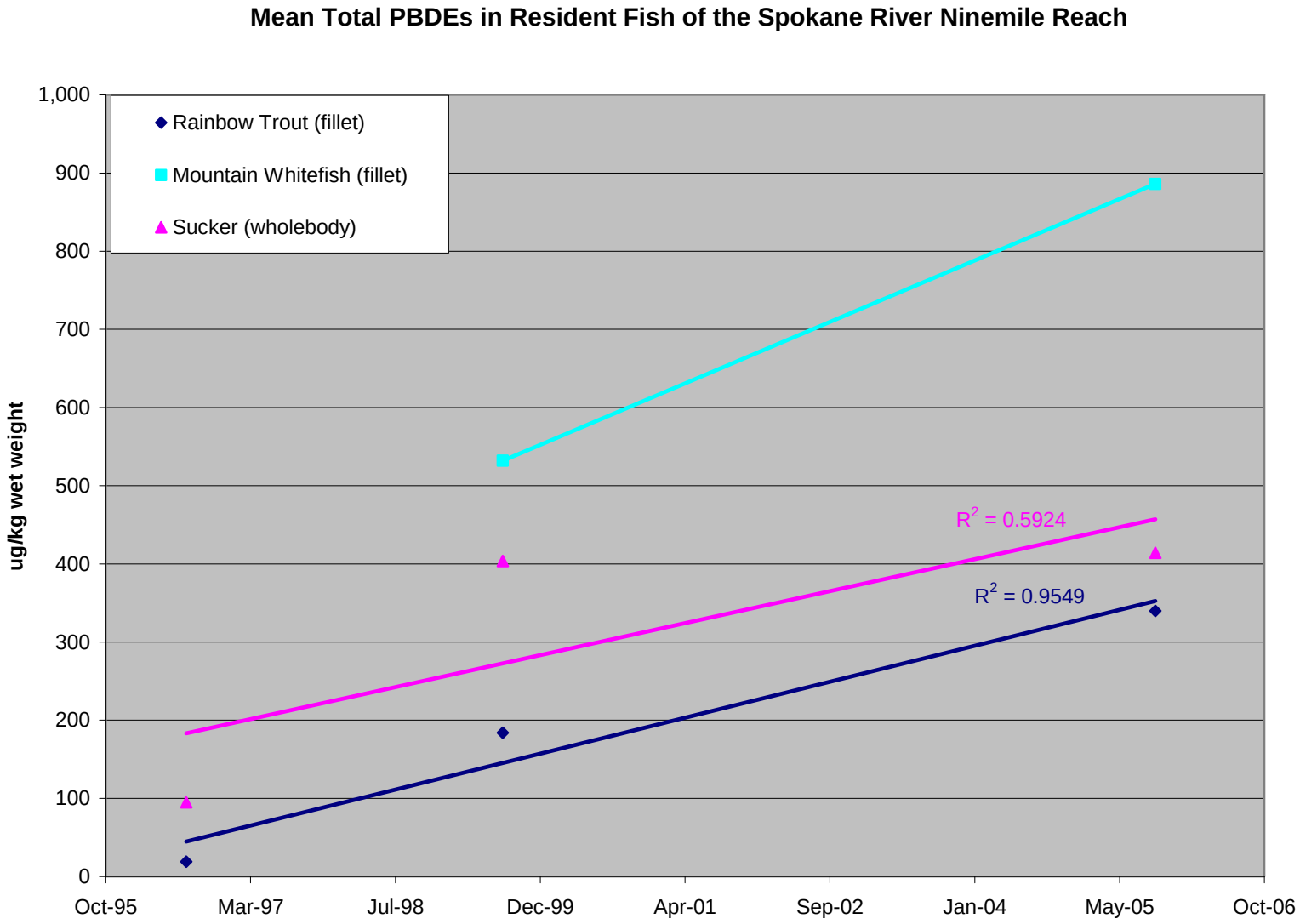
Levels of PBDEs are highest in mountain whitefish and least in sucker. This same pattern of bio-accumulation was seen in studies in the Canadian Columbia. That study speculated that the major exposure pathway was through food sources. Mountain whitefish and rainbow trout are predators and would have a higher exposure to these chemicals due to their position higher in the food chain.

Levels of PBDEs in the water column are quite high in the same reaches of the Spokane River where fish tissue levels are highest. Suspected sources of PBDEs to waterbodies include wastewater treatment plant discharges, septic systems, and industries where flame retardants used or where cars, televisions, furniture and clothing treated with flame retardants are disassembled or disposed of.

Though only two sampling sessions have occurred for PBDEs and the dataset for 1999 is not very robust, PBDE concentrations in these species seem to be increasing in most reaches of the Spokane River. The most dramatic increases are in mountain whitefish from the Ninemile reach, just downstream from the Spokane metropolitan area. Rainbow trout in this reach also appear to have seen rapid increases in PBDE body burdens.

PBDE concentrations in Spokane River fish are higher than any other fish sampled in the Columbia River Basin. The highest samples from the Spokane are twenty times higher than the highest sample recorded elsewhere in the Columbia Basin. The only other portion of the basin that has been extensively sampled is the Canadian Columbia River in the 50 miles immediately north of the border. The highest concentration of total PBDEs (sum of 47 and 99) in the Canadian study (100 ug/kg mountain whitefish fillet in 2000) is one tenth the highest mountain whitefish fillet concentrations recorded in the Spokane River (1,019 ug/kg in a 2005 sample or 940 ug/kg in a 1999 sample).

Washington Ecology has sampled statewide for PBDEs and the concentrations found in the Spokane River are one to two orders of magnitude higher than those found elsewhere in the state. The highest recorded levels of PBDEs in fish worldwide are over an order of magnitude higher than those levels found in the Spokane River.


Mean Total PBDEs in Resident Fish of the Spokane River Ninemile Reach
ug/kg wet weight
1,000
900
800
700
600
500
400
300
200
100
0
Oct-95
Mar-97
Jul-98
Dec-99
Apr-01
Sep-02
Jan-04
May-05
Oct-06
Rainbow Trout (fillet)
Mountain Whitefish (fillet)
Sucker (wholebody)
R2 = 0.5924
R2 = 0.9549

PCBs

Fish advisories for PCBs are still in place in the Spokane River. These advisories list safe amounts of fish per week by species and reach of the river. Currently there are PCB based advisories for the area between the stateline and ninemile dam and also for Long Lake. Washington Department of Health uses 13.3 ug/kg total PCBs as background for rainbow trout. Though the limits for fish consumption will be increased as PCB concentrations in fish decrease, it is likely that there will be advisories in place until background levels are reached.

Studies of effects of PCBs on fish species include:

- **7% mortality has been recorded in adult zebra danios at 1,100 ug/kg whole body wet weight of PCBs (15 congeners) The same study shows 18% mortality at 2,6000 ug/kg PCBs. (Orn, 1998*)***
- Significantly increased Ethoxyresorufin and Ethoxycourmarin O-deethylase (EROD) activity in liver was noted in immature common carp and rainbow trout at 100 ug/kg wholebody concentrations of PCBs. (Melancon, 1983)
- 50% Increase in Aryl Hydrocarbon Hydroxylase (AHH) activity in liver in rainbow trout at 329 ug/kg wholebody concentrations (Janz, 1991)
- Altered thyroid hormone tissue were recorded in Coho salmon at 110 ug/kg wholebody concentrations of PCBs. (Meador, 2002)

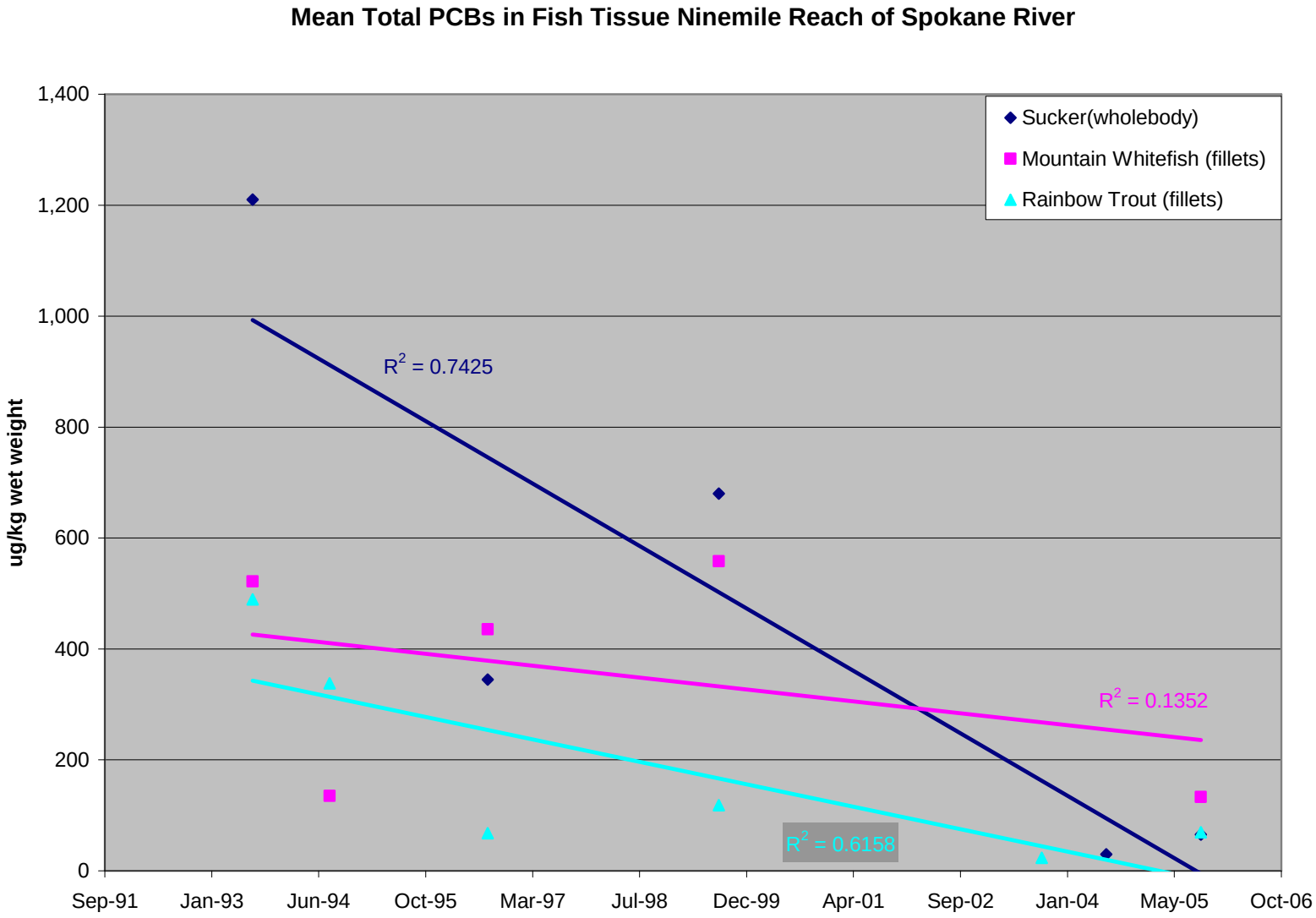
Total PCBs in Spokane River Fish (ug/kg wet wt.)

Reach	River Miles	Species	1999 Samples (or as stated)			2005 Samples			Significant Change?
			N	mean	Range	N	Mean	Range	
Fillet Samples									
Plante Ferry	84 - 86	Rainbow Trout	5 discrete	458	70 - 1,610	3 composite	55	48 - 68	No
Mission Park	74.5 - 78	Rainbow Trout	5 discrete	200	126 - 398	3 composite	153	118 - 220	No
		Mountain Whitefish	5 discrete	320	162 - 478	3 composite	234	203 - 280	Decrease
Ninemile	62 - 65	Rainbow Trout	7 discrete	119	64.8 - 363	3 composite	73	46 - 94	Decrease

		Mountain Whitefish	6 discrete	558	172 - 2,170	3 composite	139	86 - 172	Decrease
Upper Long Lake	50 - 57	Mountain Whitefish				3 composite	43	36 - 55	Decrease
Lower Long Lake	39 - 41	Mountain Whitefish	*3 discrete?**	*108*	*71 - 150*	6 discrete	76	<9.6 - 190	
Wholebody Samples									
Stateline	95.5 - 96.1	Largescale Sucker	1 composite	120		3 composite	56	16 - 77	
Plante Ferry	84 - 86	Largescale Sucker	*1 composite***	*1,230*		3 composite	122	91 - 180	
Mission Park	74.5 - 78	Largescale Sucker	1 composite	445		3 composite	1,823	1,100 - 3,00	
Ninemile	62 - 65	Bridgelip Sucker				3 composite	69	52 - 94	
		Largescale Sucker	1 composite	680					
Upper Long Lake	50 - 57	Largescale Sucker				3 composite	327	160 - 510	
Lower Long Lake	39 - 41	Largescale Sucker	*1 composite****	*784*		3 composite	254	109 - 396	

* Samples collected in 1994
** Samples collected in 1993
*** Samples collected in 1992

Levels of total PCBs in resident fish in most reaches of the Spokane River are dropping below the body burdens where effects have been documented for rainbow trout (100 ug/kg).


Mean Total PCBs in Fish Tissue Ninemile Reach of Spokane River
ug/kg wet weight
1,400
1,200
1,000
800
600
400
200
0
Sep-91
Jan-93
Jun-94
Oct-95
Mar-97
Jul-98
Dec-99
Apr-01
Sep-02
Jan-04
May-05
Oct-06
Sucker(wholebody)
Mountain Whitefish (fillets)
Rainbow Trout (fillets)
R2 = 0.7425
R2 = 0.1352
R2 = 0.6158

As PCBs have been banned for several decades sources are generally known contaminated sites, as yet undiscovered dump sites and contaminations in sediment.

Washington Ecology has compared average statewide sample data for PCBs to the concentrations found in Spokane River fish and found the levels to be roughly comparable or the Spokane River fish are slightly higher.

References:

Alcock, Ruth E.; Sweetman, Andrew J.; Prevedouros, Konstantinos; jones, Kevin C.; Understanding levels and trends of BDE-47 in the UK and North America: an assessment of principal reservoirs and source inputs; Environment International 29 (2003) 691-698

Alaee, Mehran; Arias, Pedro; Sjodin, Andreas; Bergman, Ake; An overview of commercially used brominated flame retardants, their applications, their use patterns in different countries/regions and possible modes of release; Environment International 29 (2003) 683-689

Elliot, John E.; Wilson, Laurie K.; Wakeford, Bryan; Polybrominated Diphenyl ether Trends in Eggs of Marine and Freshwater Birds from British Columbia, Canada, 1979 – 2002; Environmental Science and Technology 39 (2005) 5584-5591
Samples of eggs from four aquatic bird species were collected from four sites in Canada, including osprey eggs from the vicinity of Castelgar along the Columbia River. Concentrations of 13 PBDE congeners were tested for.

ERED database http://el.erdc.usace.army.mil/ered/Index.cfm

Hale, Robert C.; La Guardia, Mark J.; Harvey, Ellen P.; Mainor Matteson t.; Duff, William H.; Gaylor, Michael O.; Polybrominated Diphenyl ether flame retardants in Virginia Freshwater Fishes (USA); Environmental Science and Technology 23 (2001) 4585 - 4591

Janz, D.M. and C.D. Metcalfe; "Relative Induction of Aryl Hydrocarbon Hydroxylase by 2,3,7,8-TCDD and two Coplanar PCBs in Rainbow Trout (*Oncorhynchus Mykiss*)" Environ Tox & Chem 10:917-923.; 1991

Johnson, A., Results from Analyzing PCBs in 1999 Spokane river Fish and Crayfish Samples, September, 2000 Washington Department of Ecology Publication No. 00-03-040

Memo relaying sampling results for fish tissue in the Washington portion of the Spokane River tested in 1999 for PCBs (aroclor and congeners (65 resident fish of 4 species were sampled at 7 sites. Results from both discrete wholebody samples and composited fillet samples

Johnson, A., Serdar, D., Davis, D., Results of 1993 Screening Survey on PCBs and Metals in the Spokane River, April 1994; Washington Department of Ecology Pubilcation No. 94-e24 with July 11, 1994 memo to Carl Nuechterlein from Dale Davis and Dave Serdar with corrections.
Discussion of 1993 sampling results for sediment and fish tissue in the Washington portion of the Spokane River tested for PCBs (aroclors), lead, cadmium, mercury, copper and zinc. Significant contamination was found for lead, cadmium, zinc and PCBs. PCBs were elevated in fish and sediment in the vicinity of Spokane. 17 composite samples of resident fish from 9 species were sampled at 5 sites. Results are from both wholebody and fillet samples. One sediment and one waters sample were collected at each of the 5 sites. Water samples were tested for metal only.

Johnson, A., 1996 Results on PCBs in Upper Spokane River Fish, Washington Department of Ecology Memo to Carl Neuchterlein and Dave Knight, Washington DOE Publication 97-304, July 8, 1997

Johnson, A., Seiders, K., Deligeannis, C., Kinney, K., Sandvik, P., Era-Miller, B., Alkire, D., PBDE Flame Retardants in Washington Rivers and Lakes: concentrations in Fish and Water, 2005-06; August 2006; Washington Department of Ecology Publication No.06-03-027
Data on 13 PBDE congeners in 120 fish fillets and 23 whole fish sampled from 32 sites in Washington State (14 in the Columbia Basin) are discussed in this report. 20 species were sampled. 16 SPMD sampled for water column PBDEs were also collected in 2005 – 2006 (6 sites in the Columbia Basin). The highest levels in the state were encountered in the Spokane River area.

Johnson, A., Olson, N., "Analysis and Occurrence of Polybrominated Diphenyl Ethers in Washington State Freshwater Fish"; Arch Environ Contam Tox 41:339-344 2001
Discusses method to analyze for PBDEs and sample data from fish from 7 waterbodies in Washington State (6 in the Columbia River Basin) collected from 1994 to 1999. Six species of fish were sampled, both fillet and whole for 5 PBDE congeners.

Law, Robin J.; Alee, Mehran; Allcin, Colin R.; Boon, Jan P.; Lebeuf, Michel; Lepom, Peter; Stern, Gary A.; Levels and Trends of poly brominated diphenylethers and other brominated flame retardants in wildlife; Environment International 29 (2003) 757-770

Lower Columbia River Estuary Partnership; Lower Columbia River and Estuary Ecosystem Monitoring: Water Quality and Salmon Sampling report (2007)
Discusses SPMD water samples and juvenile salmon samples collected in the Lower Columbia River in 2005 and 2005 that analyzed for PCBs, PBDEs and chlorinated pesticides.

Meador JP, TK Collier and JE Stein; "Use of tissue and sediment-based threshold concentrations of polychlorinated biphenyls (PCBs) to protect juvenile salmonids listed under the US Endangered Species Act" Aquatic Conserv: Mar. Freshw Ecosyst. 12:493-516; 2002

Manchester-Neesvig, J.B., Valters, K., Sonzogni, W. "Comparison of Polybrominated Diphenyl Ethers (PBDEs) and Polychlorinated Biphenyls (PCBs) in Lake Michigan Salmonids"; Environ Sci Technol v. 35 n6 2001

Melancon, M.J. and J.J. Lech; "Dose-effect relationship for induction of hepatic monooxygenase activity in rainbow trout and carp by Aroclor 1254" Aquat Toxicol 04:51-61.; 1983

Murhead EK, AD Skillman, SE Hook, ER Schultz; "Oral Exposure of PBDE-47 in Fish: Toxicokinetics and Reproductive Effects in Japanese Medaka (*Oryzias latipes*) and Fathead Minnows (*Pimephales promelas*)" Environ Sci Technol 40:523-528; 2006

Orn, S., P.L. Anderson, L. Forlin, M. Tysklind, L. Norrgren; "The Impact on Reproduction of an Orally Administered Mixture of Selected PCBs in Zebrafish (Danio rerio)"Arch Environ Contam Toxicol 35:53-57; 1998

Rayne, S., Ikonomou, M.,Antcliffe, B., "Rapidly Increasing Polybrominated Diphenyl Ether Concentrations in the Columbia River System from 1992 to 2000"; Environ Sci Technol Vol 37 No 13 2847-2854; 2003
Comparison of fish tissue and sediment data on PBDE levels from the Columbia, Kootenay and Slocan Rivers in Canada. Fish tissue data was collected from mountain whitefish and sucker at 5 locations between 1992 and 2001. Fish were sampled for 13 PBDE congeners and some were sampled for PCBs and dioxin. Sediment was sampled at 10 sites and tested for 8 PBDE congeners in 2001. Levels of PBDEs in fish were found to have increased 12 fold in mountain whitefish between 1992 and 2000.

Rayne, Sierra; Ikonomou, Michael G.; Polybrominated diphenyl ethers in an advanced wastewater treatment plant. Part 2: Potential effects on a unique aquatic system; NRC Canada(2005)
Samples of PBDEs in municipal wastewater treated aqueous effluent being discharged to Okanogan Lake were sampled for PBDEs.

Rayne, Sierra; Ikonomou, Michael G.; Reconstructing Source Polybrominated diphenyl ethers congener patterns from semipermeable membrane devices in the Fraser River, British Columbia, Canada: comparison to commercial mixtures; Environmental Toxicology and Chemistry 21; 11 (2002) 2292-2300

Seiders, K., Deligeannis, C., Kinney, K., Washington State Toxics Monitoring Program: Toxic Contaminants in Fish Tissue and Surface Water from Freshwater Environments, 2003, May 2006, Washington State Department of Ecology Publication No. 06-03-019

Serdar, D. & Johnson, A.; PCBs, PBDEs and Selected Metals in Spokane River Fish, 2005; Washington Department of Ecology Publication No 06-03-025
Study of PCB, PBDE, lead, cadmium, zinc and arsenic levels in six resident fish species at 6 sites in the Washington portion of the Spokane River. Samples were collected in 2005 and included both fillet and wholebody composite samples.

Serdar, D. & Kinney, K..; Spokane River PCBs Total Maximum Daily Load Draft, June 2006; Washington Department of Ecology Publication No 06-03-024
Uses data from earlier Ecology studies, calculates current loads and sources of PCBs and reduction necessary to meet state water quality standards.

Song, Min; Chu, Shaogang; Letcher, Robert J.; Seth, Rajesh; Fate, Partitioning, and Mass loading of Polybrominated Diphenyl Ethers (PBDEs) during the Treatment Processing of Municipal Sewage; Environmental Science and Technology 40 (2006) 6241-6246

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Washington Department of Health, Evaluation of Polychlorinated Biphenyls (PCBs), March 27, 2001
Data collected by Washington Dept. of Ecology (Johnson, 2000) was used to evaluate the need for a fish advisory for PCBs in Spokane River fish.

Washington Department of Health, Evaluation of Polychlorinated Biphenyls (PCBs) in Fish from Long Lake (a.k.a. Long Spokane), April 25, 2005

Data collected by Washington Dept. of Ecology in 2001 was used to evaluate the need for a fish advisory for PCBs for fish from Long Lake on the Spokane River. 32 composites samples (fillet and whole) of 5 resident fish species were collected at two locations in Long Lake and sampled for PCBs. Bass were also sampled for mercury levels. Meal limits were set for both contaminants.

Watanabe, Isao; Sakai, Shin-ichi; Environmental Release and behavior of brominated flame retardants; Environment International 29 (2003) 665-682